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Director

Growing the Idaho Potato

(Revised)

By E. R. BENNETT

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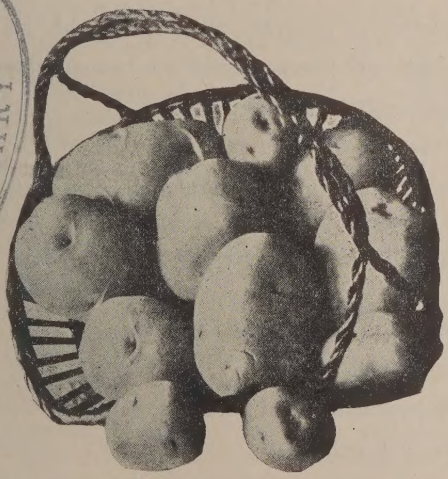

COOPERATIVE EXTENSION SERVICE IN AGRICULTURE
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This Bulletin Tells

Why Idaho acres grow more potatoes than the average acres in the United States.

What soil to select for potatoes and how to prepare it.

How and why crops should be rotated.

Which varieties of potatoes are best in this state.

How to select seed potatoes and how to cut them.

How to plant, cultivate, and irrigate.

How to harvest.

How to build and use a storage dugout, and how many potatoes it will hold.

What potato diseases are present in Idaho and how to fight them.

What insect pests attack Idaho potatoes.

How to grow seed.

What really happens when potatoes "run out."

What to do with culls.

And a hundred and one other things that will help almost any grower to solve his specific problem.

Growing the Idaho Potato

By E. R. BENNETT*

IDAHO is excelled by only one state in the Union in the yield per acre of potatoes. Our total production also has increased during the past few years from 5 or 6 million bushels per year to more than 24 million bushels in 1930-31, bringing the State up to third place in potato production.

The yield per acre has varied from year to year but on the whole has increased steadily from 183 bushels per acre, for the 10 year average, 1914-24, to 196 bushels per acre for the past eight years, and 220 bushels per acre for the past year.

Figures of total production are of interest to the grower only because of their bearing on market demands and prices. Yield per acre, cost of growing, and the quality of the product, are more important considerations to the man who grows the crop. However, from the standpoint of the State, total production figures are of great importance. The State of New York produces more potatoes than are grown in Idaho, yet New York finds it necessary to go outside its boundaries for its supply of this vegetable. Of Idaho's crop, more than three-fourths is sold outside of the State, thus making a balance of trade that amounts to several millions of dollars annually.

The yield per acre is the average for the whole State and includes not only the high-yielding irrigated lands of the State, but also a very considerable area of unirrigated land that is usually too deficient in moisture to produce a maximum yield. Few, if any, districts of the United States can produce greater yields per acre than the irrigated lands of Idaho, nor can the crop be produced in other sections of the country at a less cost per unit measure.

Quality in potatoes is difficult to measure, yet it is well known that the quality of potatoes of any given variety differs materially with conditions of soil and climate. In this respect, properly grown potatoes from all parts of Idaho will compare favorably with those grown in any other part of America.

Since more desert lands have come under cultivation and more profitable rotations have replaced the old systems of farming, the Idaho potato has taken its place in the markets of the country in quantities comparable with those from the great potato-producing states of the East. In the meantime it behooves the grower to learn the peculiarities of climate and soil

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with which he must contend, to the end that he may profit by the experience of those who have mastered the essentials for success.

I. Botany of the Potato

THE so-called Irish potato (*Solanum tuberosum*) belongs to the nightshade family. It is sufficiently closely related to the tomato that the stems of the two species may be so grafted together that a plant will bear potatoes below ground and tomatoes above. The potato differs quite materially, however, from all other members of the family both in general botanical structure and in habit of growth and reproduction.

Studying the potato where the potato grows

The edible portion of the plant, the tuber, is really an enlargement in an underground stem or stolon. We frequently hear the tuber spoken of as a root. If a plant be examined, particularly at about the time it is in bloom, it will be readily seen that, whereas the plant up to that time has had no indication of tubers, there will be small stems growing out from the main stem a short distance above the old seed piece. Disease or mechanical injury may cause these stems to grow above ground or at the junction of the leaves and stem. The habit of growth of these stems differs with the variety of the potato. In some cases they are short, so that the tubers of the plant are clustered closely around the old seed piece. In other varieties the tuber stems may be very much elongated or may continue through and beyond the

first tubers, giving the potatoes the appearance of having been strung on a thread.

These stems never grow from a root, however, nor do roots grow from the tubers. In the early stages of growth of the tuber there is probably little more starch and other plant food in its structure than is contained in other parts of the plant. But, at the end of the growing season, the plant food that has been developed by the leaves during the growing season has been largely transferred to the tuber or perennial part of the plant. This habit is practically the same as that followed by asparagus, rhubarb, Canada thistle, and all other plants that retain their living parts from year to year below ground. This being true, the potato, though treated as an annual, is a true perennial and each year's crop may be considered a continuation of the plants of the previous year's crop.

The potato is normally propagated asexually; that is, by cuttings of the tubers. In other words, when we plant a piece of potato we are propagating by a cutting just as surely as does the florist when he multiplies geraniums or carnations by cuttings of these plants. In its primitive state, the potato may have been normally reproduced by true seed. Under favorable conditions some varieties still produce fruit and viable seed. The production of the seed is of no particular importance to the commercial potato grower, however, for while new varieties may be secured by this means, it is impracticable for anyone to grow potatoes from seed except for the purposes of plant breeding.

The potato, although closely related to the tomato and egg plant, is quite unlike both in that it does not take kindly to a warm climate, but reaches its highest degree of perfection in districts where cool weather prevails during the growing season.

II. Soil and Climatic Requirements

Idaho Climate and Soils Adapted to Potato Growing

COOL nights with moderately warm, clear days make ideal potato growing weather. The potato is grown in the most humid sections of the country, but it is not at its best there and is subject to many serious fungus diseases that are unknown where dryness of the air prevails. Either northern latitude or high altitude produces desirable conditions, so far as temperature is concerned, for potato growing.

The potato can be grown more or less successfully in all types of soils. That soil is most congenial to the potato, however, which contains a high percentage of the mineral salts of fertility, such as phosphorus and potash. Where these are not present

in abundance, they must be supplied in the form of commercial fertilizers, which add materially to the cost of production.

Whatever may be the type of soil, it must have such a physical character that it will remain friable (loose) throughout the growing season. In the districts of the West, particularly in Idaho, there are many different types of soils, ranging from light sand to a rather friable clay, which have this characteristic of mellowness.

In general, Idaho's climate and soils are admirably adapted to the growing of large yields of high quality potatoes. The altitude and latitude combine to provide the cool nights. Low humidity, particularly in the southern part of the State, prevents leaf infecting fungi from causing trouble.

The ideal potato soils are those that tend toward a sandy loam, although the highest yield of potatoes yet observed by the writer was grown on a heavy clay loam. The essential quality for a good potato soil is that it shall remain mellow or friable till the end of the growing season. Heavy soils may, by careful handling, be kept in this condition, provided heavy rains do not occur between the planting and maturing of the crop.

Usually the type of top soil is of less importance in potato growing than the sub-soil or underlying soil. An impervious subsoil prevents the drainage of surplus water so that the upper soil, even though of light, sandy nature, may become water-logged, while a heavy soil with good under-drainage is not liable to serious packing from rains or irrigation.

Preparation of Land for Potato Growing

Newly broken sagebrush land will produce good potatoes. A maximum crop, however, is seldom, if ever, obtained from such lands. Raw soils are difficult to put into the condition of physical tilth which is most desirable, but the more probable reason for the inability of such lands to produce a full crop is that such soils are deficient in nitrogen.

The best preparation of land for potatoes is to precede the crop with alfalfa or clover. Pasture land, while harder to prepare, is good potato land. Land on which peas or vetch have been grown is usually well fitted for potato growing, though there is less organic matter left in the soil than where alfalfa or the clovers have been grown. Grain stubble gives the poorest results in yields, and potatoes grown on such lands seem more subject to scab.

Manuring Land for Potatoes

It is generally believed that fresh manure applied to land just before planting to potatoes tends to induce scab on the potatoes. Notwithstanding this belief, many of the most success-

ful potato growers in Idaho, and in other western states as well, cover the land heavily with fresh manure during the winter previous to potato planting. Where the manure is handled with a spreader, so as to be evenly distributed, there seems to be little danger of increasing the tendency toward scab from its use. Well rotted manure is preferable and if the land can be thoroughly disked before plowing, the beneficial effect will be greater and the danger from scab lessened. Twenty tons of manure per acre is not too much.

Rotation of Crops

In any rotation of crops, several objectives should be kept in view. The principal one of these, the one which ultimately includes all the others, is to secure the greatest yields per acre of our most profitable crops. This is done by first maintaining the fertility of the soil, which is difficult without a proper rotation. A proper rotation also eliminates or reduces weed troubles and retards the multiplication of insect pests and plant diseases. A successful rotation anywhere includes a legume crop, possibly a grain crop, and one that is cultivated or hoed so as to keep out weeds for at least one growing season.

Potato growers in Idaho practice several different systems of rotation, yet all of them conform to this rule. Where potato growing is the major or money crop, the most common rotation is alfalfa or clover from two to four or more years; potatoes, one or two years; grain, one or two years; then back to alfalfa or clover. Where sugar beets are grown, potatoes are best followed with beets and beets with grain.

Alfalfa provides the nitrogen and organic matter necessary to stimulate the potato into making its best growth, yet the potato does not remove any great quantity of the fertility from the soil, and grain or other crops following the potato are as good as or even better than if the land had not been cropped to potatoes.

Preparing the Soil for the Potato

In preparing alfalfa or pasture land for potatoes there are two objects to be attained. One is to kill the alfalfa or sod and the other to pulverize and loosen the soil so that it will be mellow to the bottom of the furrow.

In some districts of the West, alfalfa can be turned under just before planting time without trouble ensuing from the growth of the cut-off alfalfa crowns in the field of potatoes. In other districts much trouble is experienced when this system is followed, so that it has been found more satisfactory to double plow the land. This is best done by plowing in late fall or very early spring just deeply enough to cut the roots of the alfalfa a short distance below the crown. The plow should be followed by the harrow, which will, in case of alfalfa land, drag out most

of the short crowns which have been cut off. These crowns soon dry out and die, and no further trouble will be experienced from their growth. In case of pasture land the shallow plowing should be followed, possibly in early spring rather than immediately after plowing, by a disk harrow, with which the turned up turf should be chopped as finely as possible. The second plowing is done shortly before planting time. This time the plow is run as deeply as is practical, from eight to twelve inches, depending on the depth and type of soil and the horsepower available.

Well prepared soil, shallow fall plowed alfalfa land, deep plowed just before planting

With the second plowing, two exceedingly desirable soil conditions must be kept in mind. First, the retention of the soil moisture that has accumulated during the winter is of the utmost importance. No subsequent watering or rains can take its place. This is of special importance in the more arid districts that are subject to heavy, drying spring winds. Second, while this is being kept in mind, the grower must not lose sight of the particular object of the second plowing, which is to secure a loose, mellow seed bed. The alfalfa crowns or fine chunks of sod that were left on the top of the land by the first plowing and harrowing will be turned to the bottom of the furrow by the second plowing, where they will be out of the way of the subsequent work and where they will help maintain that porous condition of the soil needed by the potato.

The importance of thorough preparation of the soil for the potato can hardly be over-emphasized. No subsequent cultivation or treatment can make up for poor or careless preparation of the seed bed. The potato is different from most other agricultural crops in that where most seeds start soonest and grow best when planted in a soil well compacted just under the surface, the potato demands a loose condition of the soil at planting time and all during the growing season. Notwithstanding this fact, there is a greater loss of the potato crop in the arid districts because of planting the potato in soil that has an insufficient amount of moisture than from any other cause excepting disease. Thus great care must be exercised, particularly in dry windy weather, to harrow potato land as fast as it is plowed. A rule followed in some of the most successful potato growing districts, and one that should be adhered to everywhere, is never to let the teams leave the field either at noon or night until the land that has been plowed during that half day has been thoroughly harrowed.

III. Seed Potatoes

Varieties and Seed

PLANTING "just potatoes" is not profitable. In some districts it is claimed that potatoes can be grown but that there is no market for them. In most cases, except where there are no shipping facilities, the reason for lack of market is that too many varieties are grown, many of which are undesirable. Even though the varieties are of equal value, the fewer that are grown in a community the better it is for the industry. Four or five varieties are sufficient for the whole State.

Netted Gem Potatoes, shallow eyes and square at the stem end

In the eastern markets the reputation of Idaho potatoes is based largely on one variety—the Idaho Russett (Netted Gem). The market does not like varieties mixed in a shipment and

buyers do not favor communities where several varieties are grown. As a result, those potato growing districts are most prosperous which have the fewest varieties.

For early maturing varieties, the old standard Early Ohio, Bliss Triumph, and Irish Cobbler that have been known over the United States for several years are found satisfactory in all districts of the State. All of these varieties as grown in Idaho, are of high quality. Inasmuch as early varieties are sold more or less locally or go on the market before the main crop is harvested, multiplicity in these is less serious than for late stock.

Some markets are partial to either a red or white potato, depending on the traditions of the place. Fortunately there are strains of both Ohios and Bliss Triumphs which are white (bud variations), though those most commonly grown are red.

Seed Potatoes an Important Factor

Generally speaking, the yield of the potato crop in any locality is determined more by the quality of seed used than by the variety planted. Not many years ago the general practice of securing seed for planting was to select the stock from the cellar. Frequently the stock planted was that which remained after the market potatoes were sold. In other words, the culls of the crop were used for seed. Those were the days before the many diseases now common to the potato were disseminated. No commercial grower of potatoes, at present, follows this practice and growers now have come to the point where it is considered of questionable expediency to plant any stock unless it was grown expressly for seed purposes.

In districts with a cooler climate; that is, in districts of northern latitude or high altitude, the same stocks of potatoes may be used from year to year without deterioration if the factor of disease is eliminated. Where this is done the question always arises as to what sized potatoes are best for seed.

This is determined by the average size of the stock grown. If the soil and growing conditions are such that only comparatively small tubers are produced, the stock still may be very good for seed. Where heavy yields are secured and the smaller tubers are selected for seed the tendency is for the stock to deteriorate, inasmuch as at least a percentage of these small tubers are the product of weak plants. If the stock is field selected so that the grower knows that the small tubers are the late set from high yielding plants, the small ones are as desirable for seed, and in fact more desirable, than the large tubers, inasmuch as large tubers are coarser celled and when cut for seed have a higher percentage of cut surface. For this reason potatoes that make poor yields because of poor soil or lack of other favorable growing conditions, rather than from a lack of vitality or disease, may be desirable seed.

The trend in commercial districts where high yields of potatoes are secured is for the stocks to gradually deteriorate from year to year. The remedy is either to grow stocks especially for seed or renew the stock frequently by bringing in seed that is grown especially for seed purposes.

The question also arises as to whether or not stocks of poor type are desirable for seed purposes. Experiments tend to indicate that unless the bad type of tubers is the result of a diseased condition, usually "giant hill" or "spindle tuber," it is not a factor in the value of stock as seed, other than that ill-shaped potatoes may not cut and plant to as good advantage as those of a better type.

Since the growing of seed potatoes as a business has become a common practice in those districts where disease-free stock is easily secured, the problem of seed potatoes has changed very materially from what it was a few years ago. Good seed stock unquestionably may be grown in any of the commercial potato growing districts. The question for the growers to decide is whether it is more economical to produce such stock themselves or to secure it from districts that are especially adapted to the production of desirable seed stocks.

To grow potatoes that are free from disease and of a desirable size and type for seed purposes, several points should be considered. It is at least desirable to plant late in order to avoid the hot weather; to plant excessively large seed pieces so as to increase the number of tubers per plant; to give the plants very much more space in the row so that the individual plants may be observed and to isolate the plot from any other potato stocks in order to avoid contamination from diseased plants. This means reduced yields, increased cost of production, and more care. Hence most growers find it more profitable to secure seed from special seed districts each year or two to renew their stocks, rather than to attempt to grow potatoes for seed purposes.

Seed from the Field

In selecting seed potatoes from the field, more than just the character of the individual tuber should be considered. Many apparently perfect tubers may be found on plants that did not make a satisfactory growth or yield and on plants that have succumbed to disease before full maturity is reached. A good percentage of the medium, uniform, healthy plants that are typical of the variety will be found to have tubers that are likewise uniform, typical, and satisfactory in size and numbers. The person who makes the selection must learn the discriminating factors, so that a majority of the plants selected and dug can be retained for seed. In this work, it is not expected that all the tubers from these best plants will be retained for seed, although those tubers which may not be entirely perfect in every way, if from perfect plants, will tend to reproduce perfect potatoes.

Every grower who wishes to improve his own stocks should select seed potatoes from the field, saving only the best tubers from the most perfect plants, so as to have enough of such seed to plant at least a seed plot each year. Only in this way can the type and yield of a variety be brought up to its highest standard and maintained. The average field is composed of a mixture of types and, in many cases, of varieties that can hardly be distinguished in the bin but which are evident to even the casual observer if the plants in the field are given a bit of study at the time of maturity. On the other hand, field selection of seed potatoes will avail little or nothing unless the field from which the stock is selected is free from such diseases as mosaic, spindle tuber, and leaf roll. They are spread by the inoculation of healthy plants by insects which have fed on diseased plants. These diseases do not become apparent for some time after inoculation, hence there is no way of determining those plants that have been contaminated, the tubers from which will likely develop the disease the following year.

Keeping Seed Potatoes

The ideal method of keeping seed potatoes over winter is to leave them in the ground till spring. Unfortunately this is only possible when the soil does not freeze because of lack of cold weather during the winter or because an early snow blanket prevents freezing deeply enough to destroy the tubers. The next best method is to approximate this natural condition by holding the tuber, as nearly as possible, in a uniform condition of temperature and moisture during the dormant period. This is best accomplished by keeping the potatoes in bins in a well ventilated, earth-covered dugout. The temperature should be held as nearly as possible at 40° F., although no harm will be done if the temperature of the cellar goes down as low as 32° F. Potatoes piled deeply in bins, particularly if there is no rack floor under them or if there are many decayed potatoes in the pile, will generate considerable heat so that the tubers in the center of the bin may be many degrees warmer than at the surface. No exact data are available as to the effect of heating of potatoes in pits or bins, but observation indicates that heated potatoes are less likely to grow when planted, than are those that have been subjected to a low temperature. In either case, so-called "chilled" or "frozen" potatoes can be detected, while those that have been killed from heating may appear firm at planting time.

Cutting Seed Potatoes

The matter of whole or cut seed, as well as how and when seed potatoes should be cut, is a rather vital problem to the grower. Experiments in Idaho have indicated that under normal conditions and with the generally accepted idea of seed, the planting of whole potatoes has not proven profitable. However,

there is a strong and growing tendency for growers of commercial potatoes to demand small (2 ounce) whole seed. The reason for this change is that growers are finding it desirable to plant later in the season than has been generally practiced, and because late planted cut seed is prone to rot in the ground since at that time the soil is apt to be hot and dry. The objection to whole seed has been that too great a number of tubers per plant resulted from their use, accompanied by a high percentage of undersized tubers. We are learning now that this difficulty can be avoided by giving the plants more space in the row so that while each plant produces a greater number of tubers it may have a better opportunity to develop the tubers to marketable size. A given size whole tuber should not produce any more stems than the same size cut tuber and the fact that it does, indicates that a greater percentage of the plant food of the whole tuber is used in starting the stem growth than is the case with the cut tuber. There seems to be a growing tendency toward a high percentage of decay of cut seed in the ground with its accompanying missing and weak plants.

Where common seed stock or that of unknown origin is used, it is still probably safest to use from 6 to 12-ounce seed and cut to 2-ounce pieces. With the use of certified seed, that is, seed that is known not to carry any considerable percentage of the virus diseases, the growing tendency is to use 2-ounce or even smaller tubers for planting.

Therefore, where clean, well bred, disease-free seed is used, small, whole seed may be more economical and a better stand of plants assured than from the use of the best large seed tubers.

Generally potatoes are cut into too small pieces. Experiments extending over long periods show that the greatest yield of marketable-sized potatoes is obtained when seed pieces weighing 2 ounces are used.

It should be borne in mind that the tuber is a stem, and, like the stems of other plants, most varieties of potatoes have more buds than can be supported by the plant food of the tissues. With the system sometimes practiced of cutting out eyes of the potato to plant, there is not enough plant food retained with the bud to support the young shoot until it develops a root system. A spindly, weak plant results, that never reaches the size and productivity that is attained where the seed piece is larger.

The same result in the way of weak plants frequently occurs with large cut pieces when, because of adverse weather conditions, the cut surface rots before the sprouts get a start.

With most varieties of potatoes, it does not pay to examine the tuber for eyes. Cut the potato so as to have as little cut surface as possible. If the pieces are 2 ounces in size there is likely to be at least one bud on the piece, which is enough.

Several machines for cutting seed potatoes are on the market, but comparatively little is gained in time by using them and it is doubtful if as good work can be done with them as by hand work. A simple yet efficient contrivance for cutting seed potatoes is to drive a case or paring knife into the end of a piece of board in such a way that the operator can sit on the board and push the potato across the upright blade of the knife. An elaboration of this knife in the board is used extensively in some districts in the form of a slat-bottom hopper in which several sacks of potatoes can be placed. The potatoes roll down to the hand of the operator in front of the hopper and the knife is set up on the edge of a sack-holding frame so that as the potatoes are cut the pieces fall into the sack. By this means the number of motions used in cutting the seed is reduced and the amount of work turned out in a given time increased.

Potatoes should be planted as soon as is convenient after they are cut. Some growers prefer to let the cut surfaces heal (dry over) before planting. This is sometimes effected by sprinkling air-slacked lime, sulphur, gypsum, or road dust, on the freshly cut pieces. The pieces may be handled rather better if dried off in some such way, but we have no evidence that anything is really gained by such practice. Most growers take care not to cut a very great quantity of potatoes ahead of the planter for fear that rains or accident may cause a delay, in which case the cut seed may deteriorate.

IV. Planting, Cultivation, Harvesting

Planting

THE land should be thoroughly prepared before the seed is cut. In arid sections there is always danger that heavy winds will dry the soil out before or during planting time to such an extent that a poor stand of plants results. The depth of planting is frequently determined by this factor.

Where potatoes are grown under irrigation methods and anything more than a garden patch is to be planted, a machine planter should be used. The machine is also satisfactory for unirrigated land provided it can be regulated to plant at a sufficient depth and at the proper distance in the row. Planting on unirrigated land in a plow furrow is likely to be unsatisfactory, particularly where cut seed is used, because the soil is likely to dry out in the furrow and the seed to be covered with this dry soil. Because of difficulties in getting planters to do the work satisfactorily, it is sometimes more satisfactory and economical to use the hand planter or jabber type of planter. This is particularly true of cut-over land where roots and other obstructions interfere with the efficient use of the planter.

There are many types and makes of planters, all of which do good work on properly prepared soil. With all types of automatic planters greater accuracy of dropping will result if the seed pieces are of uniform shape and size.

Practically all potato fields in Idaho are planted in rows but one way. The distance between rows varies somewhat, but usually as a matter of convenience in cultivating, irrigating, and digging, the rows are planted 36 to 38 inches apart. For early potatoes, the distance between rows can be cut down to 28 or 30 inches if the crowding does not interfere with the machine work.

The distance between plants in the row is determined by the fertility of the soil or amount of moisture. For unirrigated land, considerable space must be given, or lack of moisture will cut down the size of the potatoes. Thirty inches in the row where the rainfall is scant is not too much. The size of the seed piece also should be considered in the distance of planting in the row. Large sets make bigger plants, hence the distance between plants should be somewhat greater. The distance in the row for irrigated potato land is anywhere from 8 inches on excessively rich land to 15 inches where growing conditions are not so good.

Depth to Plant

The depth to plant also varies with conditions. For unirrigated land, or where the planting is done very early in the spring, 5 inches under the level surface is not too much. With irrigation, 2½ inches is probably as deep or possibly deeper than the average grower plants. In any case, however, it is wise to plant sufficiently deep to make sure that the seed is placed in moist soil and also covered by moist soil. If this cannot be done, planting had best be discontinued till the land has been irrigated, as the chances for a satisfactory stand of plants from potatoes planted in dry soil are exceedingly poor.

Cultivation of the Potato Crop

Various systems of cultivation are followed in Idaho, their desirability depending largely on the type of soil and moisture conditions. With land which, because of its sandy texture, has little tendency to compact or bake, it is cheaper and equally effective to harrow the field with a smoothing harrow until the plants are so large as to be injured by the work. The harrowing may be commenced as soon as the planting is finished. With soils that are inclined to pack easily, better results are obtained if a deep cultivation is given soon after the planting is done. Machine planters leave a ridge over the potato row which can easily be followed, so the first cultivation can be made as well before the plants are up as after.

Why Cultivate

There are two fundamental objects to be attained by cultivation. First, to aerate the soil; second, to make plant food available. The killing of weeds is incidental and, hence, a secondary matter. While deep cultivation is desirable, especially for the first time and on heavy land, it necessarily tends to allow the soil moisture to escape, and as that is nearly always undesirable in Idaho, deep cultivation should be immediately followed by the smoothing harrow to re-establish the soil mulch broken by the cultivator.

Type of Cultivator

In some potato growing districts a special cultivator with heavy frame and 14-inch bull tongue shovels, that requires four horses, is used. With this tool the soil is loosened as deeply as the plow is run. None of the soils of Idaho seem to need this drastic treatment to prevent soil packing, provided the previous preparation has been right. For the most part, the common four or six-shovel, two-horse cultivator is used for potato work in Idaho.

Where irrigation is not practiced, any cultivator may be used that will leave the surface of the soil fine and not ridged, as the less ridging of the soil the less will be the loss of soil moisture. Neither ridging nor hilling of the potatoes is desirable for potatoes on unirrigated land, for if the seed pieces were planted sufficiently deep the tubers will be formed well below the surface, and hilling in any case necessarily causes a greater heating and drying of the soil than would occur where the surface of the soil is kept level. Frequent shallow cultivation will prevent loss of moisture and promote rapid growth. This may be continued until the plants are well in bloom or until the plant tops interfere with the work.

Where the potatoes are to be irrigated, it is well to set the cultivator in such a way as to work the soil toward the row from the start, thus forming a ridge at the row and a ditch at the middle of the inter-space between the rows. Deep cultivation of potatoes is not likely to injure the plants if it is first done before the roots have extended far into the inter-space. If deep ditching for irrigation is necessary, the earlier deep cultivation may be desirable inasmuch as the ditching will necessarily root prune the plants to some extent. The number of cultivations varies with the other conditions but, with most growers it is from three to six. The opinion is quite common that cultivation of potatoes, after the plants get partly developed, is injurious because of damage to the roots. It is probable, however, that little, if any, damage is caused in this way where irrigation is practiced. Under irrigated conditions cultivating may be continued

without damage until the size of the plants interferes with the work, which usually occurs before the plants are in bloom to any extent.

Ditching for Irrigation

Where irrigation is to be practiced the irrigation furrows must be made soon after the last cultivation. What tools are best to use for this purpose and how deep the furrows shall be made, depends both on the type of soil and the slope of the land. Of course, it is presupposed that all low spots in the potato field have been filled and all high places removed by leveling before the land is fitted for planting. If this work is not done, no system of ditching or irrigation can do other than to flood some parts of the field and leave other parts with little or no water.

Where only shallow furrows are needed, an ordinary shovel plow or the common two-row cultivator with all but one shovel removed from each inter-space will do the work satisfactorily. For flat, heavy soils, the irrigation furrows must be deep and broad so that the water will in no place reach the top of the ridges of the rows, while at the same time there will be ditch capacity sufficient so that the water can be forced quickly to the far end of the rows. In fact, the variation in size of irrigation furrows will be all the way from a shallow furrow or groove at the center of the inter-space to a furrow 18 or 20 inches wide at the top and 8 or 10 inches deep. Whether deep or shallow furrows are needed, they should be as uniform and smooth as the nature of the soil will permit to allow an even flow of water.

When and How to Irrigate

Proper irrigation of potatoes is necessary for the highest yield of the best marketable potatoes. Potatoes never should be irrigated up.

To set any date when irrigation should be done is obviously impossible. A theory which until recently has been generally accepted, was that water should not be applied until absolutely necessary. The rule was to avoid irrigation until the plants were in bloom or until the tubers were set.

Experiments during the past few years have tended to disprove this theory and it has been found that the better plan is to make sure that the plant has sufficient moisture at all times so that there is no check in its growth. In fact, the aim of the grower should be to keep the soil at as nearly the same degree of moisture as possible till the latter part of the season when further need for water is past. As no date can be set for the first application, so no interval can be given for the time between applications of water, nor can there be any time limit when water should be applied.

The length of run, type and depth of furrow, amount of water run in each furrow, and the length of time it is left running are

governed by the type of soil, moisture content of the soil, and the slope of the land. Small streams must be used on steep slopes to prevent washing and they must be left running long enough to replenish the moisture lost by transpiration and evaporation since the previous irrigation. Short runs between head ditches give a more even distribution of water with less loss from deep percolation, but the length of run should be adapted to the type of soil, longer runs being used on the heavier soils and shorter runs on the lighter soils where the absorption is more rapid.

Irrigation of potatoes; keep the row ridge dry

The water must be left on a tight soil longer than on a loose soil as it takes longer for a tight soil to absorb a given amount of water. Deep furrows have less tendency to pack the soil in the potato rows than shallow furrows and capillary rise will bring the moisture to the plant with less loss from surface evaporation. The amount of water applied at any irrigation depends upon the soil moisture at time of irrigation, which in turn depends upon the length of time since last irrigated, weather, type of soil, and the stage of growth of the plant. Rapidly growing plants in hot, dry, windy weather will soon deplete the supply of moisture and will need frequent irrigation, while small plants in cool weather may go much longer without being checked in growth by lack of moisture. The best practice is to watch the moisture condition of the soil in the potato row and irrigate to keep that moisture between the proper limits for even growth. Too much water or too little moisture will check growth.

In fact, moisture in the correct amount at these particularly critical periods is probably the most important factor in determining the type and quality in potato stocks in the irrigated districts of Idaho.

Another factor which must be kept in mind in the irrigation of potatoes is that the potato must have a mellow, porous soil in which to develop. Too heavy irrigation or heavy rains may overcome the effect of the previous preparation and cultivation of the soil to such an extent that the type and quality of the potatoes are seriously affected. From this standpoint less packing of the soil in the potato row results if the irrigation water gets to the plant roots by first penetrating the soil at the bottom of the irrigation furrow from where it is carried up, by capillarity, to where the moisture is needed. Saturation of the soil draws the soil particles together, eliminates the air spaces and when the excess water is gone, leaves the soil packed where otherwise it would be loose and mellow.

Irrigation and Frost Damage

There is always more or less danger of frost damage to the potato crop in some parts of the State. June or August frosts occasionally occur and, while the frosts that come when the plants first come up do less real damage than we anticipate, they do not improve the crop and the later frosts may cause an entire cessation of growth. Dry soils are much more subject to frost damage than wet soils. Water contains six times as much latent heat as dry soil, hence, running water into the field is the best possible prevention of frost damage. If the irrigation water can be turned on, even in only every third or fourth row, so as to be running when danger of frost is imminent, the damage may be materially lessened. In districts where short seasons are the rule and freezes frequently occur, some growers throw additional soil onto the rows by running the ditches through row spaces in the fall just after frosts have killed the plants, but before the tubers are sufficiently ripe to dig. This loose soil fills cracks made by the expansion of the growing tubers and covers those tubers that are at that time frequently exposed. This is also sometimes expedient because of the danger of heavy freezing between the time the potatoes are sufficiently ripe for harvest and the time of finishing the work.

Growers of but little experience frequently have losses from frost because of leaving dug potatoes in the field over night and from improper pitting. The potato tuber is very susceptible to freezes and every precaution should be taken to lessen liability of loss from this cause. The potato will endure a temperature in the bin of about 28° F., but if even a small area of the surface of the tuber is really frozen endless trouble ensues.

Harvesting Potatoes

While harvesting potatoes is a simple process, it requires a great amount of heavy work and is the most expensive operation in potato growing. Digging is nearly always done in the larger fields by a machine digger that elevates the potatoes over a carrier chain which separates them from the soil but leaves them on the ground to be picked by hand. Of the many types of machines used for this purpose, all leave much to be desired. At best many tubers are cut or bruised or left covered with soil.

Except for the early, green potato market, potatoes should not be dug until tubers are thoroughly ripe so that the skin will not peel off. Unripe potatoes scar easily and unless handled with exceptional care, will make a poor appearance on the market. Greater care should be taken than is common in handling potatoes both at digging and in the bins. Bruises, cuts, or any abrasions of the skin are likely to be followed by dry rot in storage. Probably the greatest amount of damage comes from the system sometimes used of pouring potatoes through chutes into the storage celler instead of carrying them to the bins.

Disposal of Culls

A problem confronting the Idaho potato grower is that of disposal of cull potatoes. With this may be classed the disposal of the whole crop in years when because of over-production which now and then occurs, there is no demand on the market for the product. In other words, the great need is for some sort of stabilizer for the crop. In other countries, where great quantities of potatoes are grown, quite a large percentage of the total crop is used in the manufacture of starch, alcohol, potato flour, and stock feed. Up to the present none of these methods of using surplus potatoes has solved the problem to the satisfaction of the Idaho potato grower. The reason for this is the inability of these products to guarantee a sufficient price for the potatoes to cover the cost of growing the crop. At present there is a renewed interest in this problem and several factories have recently been established in the State that are manufacturing potato chips, potato flour, and stock feed.

The most common method of disposing of surplus or cull potatoes has been to use them as feed for stock. Where sufficient stock is available and a proper system of feeding is maintained, potatoes fed to stock undoubtedly will bring at least the cost of producing the crop. Potatoes in not too great quantities are good feed for practically all kinds of stock. Experiments have shown that for hogs and poultry potatoes should be cooked, as raw potatoes are difficult for these animals to digest. For all stock a small percentage of concentrates, such as wheat, should be fed with the potatoes, and a ration of alfalfa undoubtedly will increase the efficiency of the feed.

In recent trials some growers have secured returns from feeding cooked potatoes to hogs that were considerably greater than the average market price of the crop. Properly fed, the value of potatoes is estimated at about 25 per cent that of corn. Although the disposal of cull potatoes by feeding has not solved the problem to the satisfaction of all growers, it is the best method of handling them for the greatest number of growers.

V. Storage and Storage Dugouts

IT IS obvious that the whole potato crop of the country cannot be marketed at time of harvest. A large part of the crop must be stored either on the farm or at the centers of consumption.

Each grower has the question to settle each year as to whether he will sell from the field or store the crop, to be put on the market during the winter or spring. It is hardly possible for any grower, except one who grows only early potatoes, to get all of his crop off at digging time every year. This being the case, every grower who aims to grow potatoes as a money crop should have some provision for storing at least a part of the crop.

Storing potatoes in pits is practiced to some extent, but the system is only a makeshift at best and is open to several serious objections. Some of the difficulties with this method are that the cost of handling is increased, the crop cannot be reached when the weather is cold, and the grower never can know whether the potatoes will be too warm to keep during the winter or will freeze.

The Western Underground Cellar or "Dugout"

The most satisfactory storage cellars found in Idaho are those of typically western or arid country origin and development. This soil-covered cellar or dugout is practicable only in countries of comparatively light rainfall, as excessive soil moisture would render the cellar unfit for storage purposes as well as cause rapid decay of the timbers. Under the moisture conditions that prevail in the irrigated districts of Idaho, there is enough moisture in the soils to prevent excessive loss of weight from fruits or vegetables stored in properly constructed dugouts, yet condensation of moisture on surfaces in the cellars seldom occurs.

Location of the Dugout

If the lay of the land permits, the dugout should be located where it will be convenient with relation to the other farm buildings. This space is the most efficient storage on the farm and is used not only as a storage cellar for potatoes and garden

produce but also as an incubator room for the poultry and to a great extent as a tool house during the summer. From the standpoint of construction, a low knoll gives the greatest advantage. Perfectly level land can be used almost as well, however, and is much better than the side of a hill, which, though sometimes used, is the poorest possible place. Other things being equal, an east and west direction, particularly if a driveway goes clear through the dugout, is to be preferred as giving the greatest ease of ventilation and greatest protection during the winter.

Construction of Dugout. Note end walls and construction of approach or vestibule

Size of the Dugout

Each square foot of floor space will carry 40 pounds of potatoes piled 1 foot deep. With good, sound potatoes there is no harm in storing at least 6 feet deep; hence one can safely estimate the capacity of a cellar at 240 pounds per square foot of floor space. Thus a cellar 36x50 feet with a 12-foot driveway will have a capacity of 288,000 pounds or about 2,800 sacks. With the driveway filled to the same depth, as is frequently done, this size of house will hold 4,200 sacks.

Dugouts are made of various dimensions. Cellars of 36-foot width have two bins and a driveway, each 12 feet in width. A wider cellar will have a correspondingly greater depth of bins to width of driveway, but such cellars are open to the objection that a greater depth of bin space makes an increasingly greater distance to carry sacks to the backwalls. But the greatest objection is that if the total width of the dugout is greater than 36 feet, it is necessary to have four rows of supporting posts, whereas up to 36 feet but two rows are required. Because of this and also because the narrower cellar is easier of construction, the 36-foot cellar is generally preferred.

Construction of Dugout. Note line of posts and rafter arrangement; braces not needed

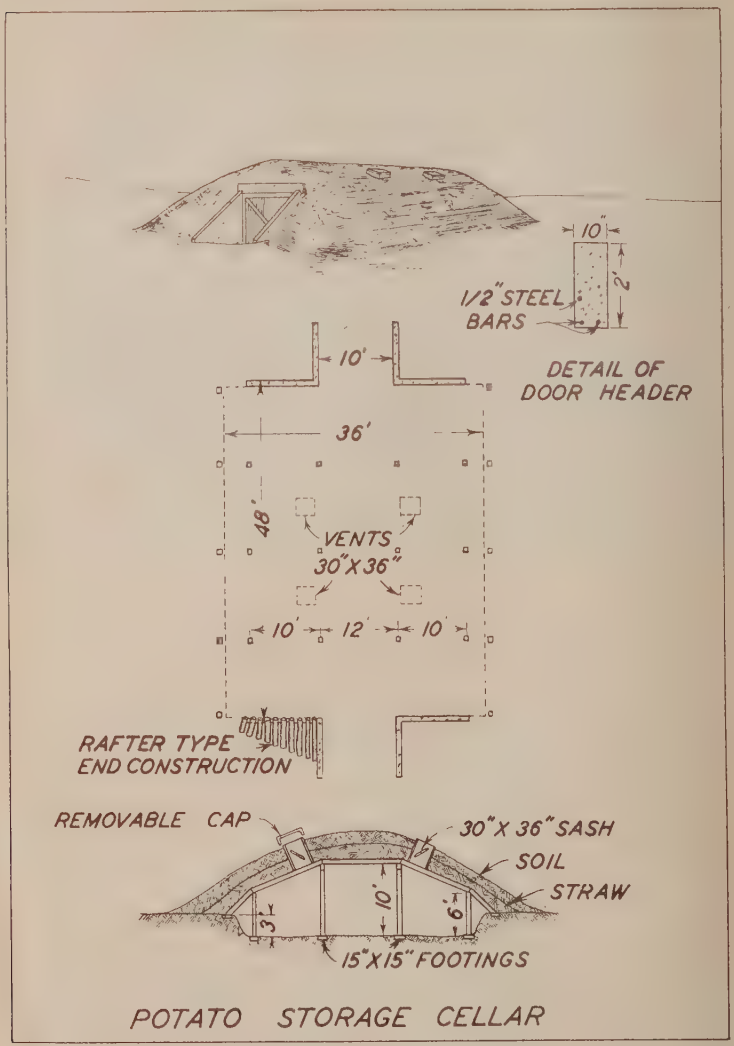
Depth of Cellars

Though dugouts of various depths may be found, a close study of the subject has shown that there is seldom any advantage in making the excavation more than 3 feet deep. A greater depth is nearly alway undesirable, as it tends to make the cellars more difficult to ventilate and more likely to be damper than desired. A still greater objection is that it necessitates either a steep pitch in the vestibules or an unnecessarily long covered vestibule. Three feet of excavation will usually provide sufficient soil for covering the top and ends of the cellar, which is all that is required. Where the soil water is close to the surface, it is sometimes necessary to build the cellar mostly above the ground, in which case the soil for covering has to be obtained elsewhere.

It is always best to have the driveway clear through the cellar, with covered approaches and doors at each end. This adds to the total cost of the cellar, but it makes for greater efficiency and ease in ventilation. In excavating, pile the soil along either side as closely as possible to the excavation so that it can be used conveniently in covering.

In many parts of Idaho side walls are not necessary, and where this is true, the cost of construction will be less than where concrete or stone walls are required. If sidewalls are not

to be used, it is well to excavate so as to have the side slope a little, for by so doing there is less likelihood that the soil will cave.



Some cellars are constructed by placing the sills for the rafters on the ground. This method is not recommended. A better method is to set a line of solid 5-foot posts, or if the sill is to be mortised into the posts, 6-foot posts, in place of the outside

wall. These should be not less than 8 inches in diameter at the small end, in case of round timbers, or 8 inches square if sawed timber is used. Place these posts not more than 10 feet apart on the line just inside the excavation. Set on solid foundations of stone or concrete so that there will be no possibility of settling. Have the foundations come somewhat above the cellar floor so as to avoid danger of decay in the bottom of the posts, which occurs when the posts are set in the ground. If the cellar is not more than 36 feet in width, two more lines of posts 6 feet either side of the center are all that will be needed to support the roof. These should be of the same dimensions as the outside posts but 11 feet long. If the cellar is more than 36 feet wide, intermediate lines of posts on each side are needed.

Framing the Roof

When good round timber is available, it may be used for both rafters and purlins. Rafters should be sound poles not less than 4 inches in diameter at the small end, and purlins should be not less than 1 foot at the small end. If sawed timbers are used, three 2x12 planks nailed together make good purlins. Sawed

Construction of Dugout. Note line of six-foot posts in place of side wall, also short rafters running from plate to sill on ground level

stuff 2x12 also makes good rafters where poles are not convenient. Place the rafters not farther apart than 15-inch centers. If posts are used instead of sidewalls, short rafters must be ex-

tended from the plate to a sill on the ground outside the line of excavation to form the sidewall. For this purpose it is best to lay a shallow sill wall of concrete 2 or 3 feet from the outside line of posts. This type of construction gives a bit more storage space and makes the cellar equally as good as one made with solid outside walls.

The ends of the cellar may be constructed in the same manner as the sides but, as greater difficulties are encountered here, it is better where possible to make substantial end walls of concrete or rock. Vestibules are made in various ways. The best construction is to continue the end walls at least a part of the length of the approach to act as a bulkhead against which the soil may be banked. The vestibule must be roofed, as rain or snow falling in the approach otherwise will run directly into the cellar.

The roof is covered with straw and earth. This is not done as a matter of economy, but because soil and straw make the best possible non-conductor of heat. Where the rainfall is heavy, it may be necessary to have a tight roof over the soil, although a properly made earth roof cellar will not leak for several years except in case of prolonged heavy rains. It has seemed to the writer that a soil roof could be cheaply water-proofed by applying a coat of road oil and sand on the finished roof. This scheme has never been tried, however, so far as known.

Covering the Roof

Over the rafters is placed hog fence, poultry fence or plain wire to support the straw and earth. Roofing boards have sometimes been used for this purpose, but wire is to be preferred, as boards tend to hold any moisture that gets into the straw, and early decay of straw, boards and rafters is encouraged. On this covering of wire, 2 or 3 feet of straw is placed. If, in the construction of the cellar, the driveway has the rafters laid flat across the purlins, the center should have enough straw to give the roof a rounded top when the earth has been placed and settled. With a properly made cellar, the earth covering may be driven over with a team after the work is started, as there should be no danger of the roof breaking through. This soil covering need not be more than 10 or 12 inches deep.

Ventilators

Ventilators or chutes should be provided when making the cellar, though the importance of ventilators, from the standpoint of ventilation, is usually over-estimated. These ventilating shafts are made in various ways. If it is desired to unload potatoes into the cellar through chutes, such chutes may take the place of ventilators and should be placed near the outside walls of the cellar at intervals of 15 or 20 feet. For convenience in working

in the cellar, provision should be made for plenty of light. This may be combined with the ventilating system; hence, if the ventilators are to be used both for lighting and ventilating the openings should be located just outside the center line of posts so as to admit light to both alley way and bins. It may be well also to have one or two good-sized cupolas or openings over the center of the drive. It should be remembered, however, that the greater the number of these openings the greater will be the danger from freezing during cold weather.

These shafts may well be made 2½x2½ feet and should project at least 1 foot above the soil covering. Tight board caps are made for both top and bottom and it is well to have a sash of glass fitted at the center of the shaft so that light may be admitted to the cellar when desired without letting in outside air.

Doors

Frequently the doors are the weakest feature of a dugout. If the doors are not properly made or do not fit tightly, freezing is quite likely to occur. Double doors that swing in from hinges at the sides are probably the most satisfactory. The doors should be double in thickness with a good grade of building paper between. If the doors are cut in sections so that the upper halves can be opened while the lower parts are closed, it will aid in ventilation.

Ventilation of the Dugout

It should be remembered that the farm potato storage dugout is primarily a cold storage. The space is partly below the surface of the ground and is well insulated to keep out heat. Ventilation should be, then, largely for the purpose of letting out the heated air and letting in colder air. If the cellar has doors at both ends, this may be quickly accomplished as there is at nearly all times enough current of air to change the air quickly in the building if the doors of both ends are opened. Sometimes it may be desirable to change the air in the cellar in winter, which may be done during the middle of the day when the temperature is above freezing. It is usually better, however, not to molest the cellar in winter except to see that the temperature does not go below the freezing point, which, for most fruits and vegetables, is about 28° F. Fall and spring are the times when closest attention must be given to ventilation. If the doors are thrown open late at night and closed early in the morning, the temperature in the cellar may be held uniformly low, even until late spring or summer. A thermometer should be kept in the dugout at all times, as one cannot place much dependence on the "feel" of the air in the cellar.

Most dugouts have only an earthen floor. Concrete floors are more easily kept clean, otherwise they are not of any particular value. Some growers use a rack floor, made of narrow strips on

2x4 supports. This allows a circulation of air under the potatoes. In case potatoes are stored in sacks, it also prevents the rotting of the sacks, which takes place rapidly where sacks are in contact with the earth. Other than this, there seems to be little difference in the keeping of potatoes, provided they are kept dry and cold.

VI. Potato Diseases and Insects [1]

Diseases

IT IS doubtful if any farm crop is subject to more diseases than the potato. This is partly due to the fact that potatoes are propagated vegetatively by cuttings from underground stems called tubers, and many diseases are thus transmitted from one season to another which would not be carried by true seed. The control of potato diseases is one of the most important problems with which the potato grower has to deal. This is especially true of the growing of seed potatoes. There are five general methods of potato disease control: seed selection, seed treatment, crop rotation, spraying, and good storage. Each of these is an important means for the control of certain potato diseases, but no one of them may be considered a panacea for all the ills of the potato.

Seed Selection may well be considered most important. Disease-free seed from tuber-indexed stock, kept clean by the use of a carefully rogued seed plot, will go far toward producing a disease-free crop.

Seed Treatment. This is discussed fully in Circular No. 58 of the Idaho Agricultural Experiment Station. It is a necessary and always an important practice and is insurance against loss from certain tuber-borne diseases.

Crop Rotation is important in reducing loss from such diseases as scab, rhizoctonia, fusarium wilt, etc., the germs of which may live in the soil from one year to another.

Spraying is an important practice in some of the more humid sections of the United States but is not necessary in Idaho due to the fact that the two diseases which it is primarily used to combat, late blight and early blight, are not serious.

Good Storage is important as a means of disease control because numerous organisms which cause serious loss by rotting of tubers in storage are held in check by low storage temperatures and good ventilation.

The control of each disease depends upon its cause. There are three classes of potato diseases when causes are considered.

(1) The discussions of potato diseases and potato insects were written by Dr. C. W. Hungerford and Claude Wakeland, Plant Pathologist and Entomologist, respectively, Idaho Agricultural Experiment Station.

These are parasitic diseases, where a definite organism or germ is responsible for the diseased condition; non-parasitic diseases, where the trouble is brought about by unfavorable environmental conditions surrounding the plant; and "degeneration" or "virus" diseases in which, although no responsible organism has been found, the juice from a diseased plant is infectious and, if introduced into a healthy plant, may cause that plant to become diseased.

Parasitic Diseases

Parasitic potato diseases are caused for the most part by fungi and bacteria, the spores or germs of these organisms being in the soil, and either on the surface or in the tissues of the tubers.

Rhizoctonia. The rhizoctonia disease is common practically every place where potatoes are grown. The fungus is present in many of our Idaho soils and may cause serious damage by killing both the roots and sprouts of the plants early in the season. Serious reduction in stand may result from this disease, especially in cold, wet weather. On the stems of the plants just below the surface of the ground the fungus often causes definite brown cankers which may girdle the stem. The resting stage of the fungus appears as dark brown or black scurf or warty spots on the surface of the tubers. Careful seed treatment, crop rotation, and good culture will help materially in the control of the disease.

Common Scab. This disease attacks only the tubers, where it forms rough, corky, brownish patches, which may entirely cover the surface of the tuber. The development of this disease is favored by alkaline and retarded by acid soils. The use of sulphur applied to the soil to increase the acidity has been successful in some states. This method has not been uniformly successful in Idaho, however. Lime and stable manure tend to favor the development of the scab organism. Green manuring will often aid in preventing the development of the disease. Careful seed treatment will kill the organisms of scab on the tubers but will not prevent infection from the soil.

Blackleg. This is, at present, one of the serious potato diseases in Idaho. The name is descriptive of the appearance of the diseased plants in that the stem of the plant from below the surface of the ground up some distance above turns black and decays. Infection early in the season may materially reduce the stand, many plants being killed before they emerge from the ground. Plants attacked later in the season turn yellow, the leaves are rolled, and the entire main stalk of the plant may finally turn dark, decay, and the plant eventually go down. Selection of seed from fields free from the disease, careful seed treatment, and care in disinfecting the planter after planting potatoes infected with blackleg will aid materially in preventing the spread of this disease. The disease is carried in infected

tubers, but there is no evidence that it will over-winter in the soil except in volunteer potatoes.

Fusarium Wilt. This disease has, under certain climatic conditions, caused considerable loss in Idaho. The fungus organism which causes the disease ordinarily attacks the plant from the soil. It plugs the conductive tubes and this causes wilting and finally death of the plant. A brown ring is often present in the stem and in the stem end of tubers of diseased plants. Planting of whole seed and long-time rotation have been recommended as control measures.

Dry or Storage Rots. Serious losses often occur from decay in storage. Several organisms may be responsible for this. Chief among these are two or more species of the fusarium fungus which may enter the tubers wherever the skin is broken and cause rapid decay, if the storage temperatures are not kept below 40° F. Care in handling, low temperature and good ventilation in storage, and disinfection of storage bins will keep these storage rots in check.

Jelly End Rot. Netted Gem potatoes are often subject to a condition known as jelly end. The jelly-like rot characteristic of this trouble develops in the pointed ends or on pointed knobby growths of tubers which have not matured normally. Several fungi and bacteria have been associated with this disease. Evidently a weakened condition of the tuber exists and several organisms may enter and destroy this watery, poorly developed tissue. Cultural practices which will cause the development of normal, well-developed tubers will help to control the trouble.

Non-Parasitic Diseases

Internal Brown-Spot. Tubers with this disease have irregular, dry, brown spots scattered through the flesh of the tuber. The spots are composed of dead cells which are evidently free from fungi or bacteria. Lack of available water has usually been considered the cause of this condition.

Heat or Drouth Necrosis. Potatoes grown in light, hot soils of some of our arid sections may develop a brown or yellow discoloration in the region of the water tubes a little way under the skin of the tuber. This darkening of the flesh of the potato may extend out to the skin and be visible from the surface. Control depends upon keeping the soil moist and digging as soon as possible, if the soil is light and the weather hot.

Virus Diseases

The so-called *"running-out"* or *"degeneration"* of strains of potatoes is caused largely, if not entirely, by mosaic, leaf roll, spindle tuber, or other similar virus diseases. These diseases are transmitted by diseased seed and are insect-borne from plant to plant. It has been proven that aphids or plant lice may spread these

maladies from diseased to healthy plants. The only sure way to detect these diseases is in the growing plant and the only sure way of control consists in using clean seed, in adequate isolation of seed fields from all diseased fields, and in constant roguing of all diseased plants. Due to the fact that it is impossible to distinguish mild infection of several virus diseases under some field conditions, it has been necessary to resort to greenhouse indexing in order to supply a disease-free source of seed for use in starting a seed plot. For the past two years it has been possible for certified potato seed growers to send to the University of Idaho at Moscow a sample of their seed for greenhouse indexing. This is accomplished by growing one eye from each tuber in the greenhouse. When the test is completed all tubers which have been shown to be healthy are returned to the growers for use as seed for a seed plot. All diseased tubers are destroyed.

Mosaic. Mosaic may be recognized by the mottled appearance of the foliage caused by light green and dark green areas on the leaf. There are several types of mosaic, some characterized by slight rolling of the leaves, others by crinkling, leaf dropping, and dwarfing. Space will not permit a discussion of all these various types. Climatic conditions and the variety of potatoes may have a marked effect upon mosaic symptoms. Severe types of mosaic may reduce the yield as much as 50 per cent the first year following infection. Although the mosaic disease is carried by the tubers, it is impossible to tell whether or not tubers are infected except by the appearance of the growing plants. Control is possible only through the use of disease-free seed, grown well isolated and carefully rogued.

Leaf Roll. An upward rolling of the leaves lengthwise is a sign of leaf roll. This may be accompanied by dwarfing, upright growth, and yellowish or purplish discoloration of the leaves. Tubers from infected plants are very much reduced in size and may have a characteristic discoloration of the inside tissue known as "net-necrosis." The sign which helps to distinguish leaf roll from rolling of the leaves due to other causes is the papery, rigid condition of the leaves. Leaf roll, like mosaic, often reduces the yield very materially the first year after infection has taken place.

Spindle-tuber. The spindle shaped tubers produced by plants with this disease have given it the name spindle-tuber. The stalks of infected plants are more or less spindling and upright, and the leaves are smaller than healthy plants. Upright spindling growth may result from lack of moisture, and the signs of spindle-tuber may be difficult to detect in a field with insufficient moisture in the soil. Spindle tuber may be transmitted from a diseased to a healthy tuber by the cutting knife. This is not true of mosaic or leaf roll.

Other Potato Diseases

Only the most important potato diseases occurring in Idaho have been discussed because of lack of space. There are a few diseases which have not yet been reported in Idaho, which should be briefly mentioned.

Late Blight. This disease is very serious some years in the more humid sections of the United States. It is doubtful whether it ever will become prevalent in the more arid potato growing sections of the Northwest.

Potato Wart. This is one of the most destructive of all potato diseases. Black, unsightly warty growths are produced instead of tubers. The disease has recently been found in some of the eatern states and every effort is being made to prevent its spread.

Powdery Scab. This disease differs in appearance from common scab in that the spots on the tubers first appear as blisters. These blisters break and disclose a brown powdery mass. Powdery scab occurs in the eastern states and on the Pacific Coast. It has not been found in Idaho.

Keeping Diseases Out

There are also other potato diseases that cause damage to the crop in various parts of the world which are as yet not known to the Idaho growers. Every potato grower is vitally interested in preventing the introduction of any of these diseases and insect pests into the State and nation. The surest way to keep them out is not to bring seed potatoes here from other states or countries unless such seed was grown and sold under certification of the state from which it came. Even then it is wise not only to inspect such seed carefully when it is received, but also to watch carefully during the growing season, where such seed is planted, so that any suspicious-appearing condition may be noted and steps taken to destroy any disease that may appear.

Insects

Idaho is fortunate in that many of the more destructive insects attacking potatoes either are not found within the State or are not yet generally distributed. A few of these are the potato flea beetle (*Epitrix cucumeris*), potato leaf hopper (*Empoasca fabae*), and the potato tuber worm (*Gnorimoschema operculella*), which are not known to occur in Idaho, and the Colorado potato beetle, which is present but not yet generally distributed in the main commercial producing sections. Discussion here is confined to only the insects of economic importance in the State.

Wireworms. Wireworms are a serious and rapidly growing menace to the Idaho potato industry. They not only greatly restrict the yield and quality of the crop attacked but render certain infested areas unfit for potato production. They are light-brown, shiny, wire-like, sluggish "worms." They are about one-half

inch long when fully grown and are the larvae of "click beetles" or "snapping beetles." The common species (*Pheletes californicus*) in the irrigated section of Idaho lives normally from three to four years in the soil. Under adverse climatic or food conditions, it may exist much longer. When larvae become mature they pass through the pupa stage in the soil in the late summer or early fall and soon change to beetles. The beetles remain in the soil throughout the fall and winter and emerge from the ground the following spring as soon as the surface becomes warm. Adults live for only a few weeks during which time they fly and are dispersed to new areas. During their brief period of activity they mate and deposit eggs in the soil. These soon hatch, giving rise to a new generation of wireworms. Wireworms in the soil may range from very young to those 4 years old or older. Thus there may be larvae of at least four generations in the soil at any one time. This explains why infested soil often remains so for years.

Wireworms cause injury by eating into immature tubers and forming burrows which later turn dark colored, leaving unsightly holes in the potatoes and making it necessary for them to be culled out or lowered in grade.

Larvae leave the tubers before harvest time. If they are immature larvae, they remain in the soil to attack the crop planted on the same piece of ground the following spring.

No direct control is known which may be considered economically practical under field conditions. Potatoes should be planted only on ground known not to be infested with wireworms. Land that has been in alfalfa for four or five years is usually safe to plant to potatoes the first year after alfalfa is broken out, provided the stand of alfalfa has been good.

In small areas, such as gardens or land producing high-priced truck crops, the soil may be nearly freed by using carbon disulphide as recommended by M. C. Lane of the United States Bureau of Entomology. The expense involved and the fact that treated land may not remain free from wireworms for more than one or two years, limits the feasibility of the use of carbon disulphide. Treatment is made by first marking off the surface in 2-foot squares as soon as the soil surface is warm in the spring. Then at the corners of the squares make a hole 4 inches deep with a stick or hoe handle. Pour into each hole 1 ounce of carbon disulphide and cover the hole tightly with soil. The field may be cultivated and planted about two weeks after treatment. Carbon disulphide is highly inflammable and explosive. Do not smoke while using it or handle it near a flame or heat.

Western Potato Flea Beetle (Epitrix subcrinata). This species is not to be confused with the common potato flea beetle, larvae of which so seriously scar and deform tubers in some of the other states.

The western potato flea beetle is important only in the early spring when the tiny, black, shiny, hopping beetles attack the potato plants as they first appear above ground. They eat numerous holes in the leaves and frequently stunt the growth. Control is readily obtained by dusting the plants and the soil surface immediately around the plants with barium fluosilicate. Beetles are also repelled by spraying the plants heavily with lead arsenate mixed at the rate of 4 pounds in 100 gallons of water or by spraying with Bordeaux mixture 4-4-50.

Colorado Potato Beetle (Leptinotarsa decemlineata). The Colorado potato beetle is known to have been present in northern Idaho since 1905 and is now generally distributed throughout the northern part of the State, having spread to Adams, Canyon, Lemhi, and Washington counties. Many small outbreaks have been completely eradicated in southern Idaho but the insects have become established in the counties mentioned. Doubtless these will spread until the pest eventually will become established throughout the State.

Beetles and larvae both feed on potato plants, quickly consuming the leaves. They are easily seen and their presence is also evident by conspicuous splotches of black excrement that accumulate on the leaves.

Beetles are oval in shape, three-eighths of an inch long by one-quarter inch wide. They are marked by five alternate black and yellow stripes running lengthwise on each wing-cover. Larvae, commonly called "grubs" or "slugs," are brick-red in color, marked with two rows of black spots on each side of the body. Larvae are semi-circular, "hump-backed" and have soft slimy bodies of glistening, repulsive appearance.

Larvae drop to the ground when fully grown and transform to beetles in the soil. Beetles winter in the soil and after emergence deposit eggs on the under sides of leaves. Eggs are a bright orange color, elongated, and are deposited in masses. There is one complete generation annually in Idaho, with a portion of a second generation in some localities.

Control, by dusting or spraying with arsenicals, is described by Idaho Extension Circular No. 42.

Cutworms. Cutworms occasionally destroy young potato plants but rarely seed pieces. They are grayish-black, greasy-looking "worms" which hide in the soil during the daytime. They come to the surface and attack the plants at night or on cool days and are best controlled by the application of poisoned bran mash. Instructions for preparation and use of the poisoned bait are given in Idaho Extension Bulletin No. 80. Infested land is often freed of cutworms by heavily irrigating, especially when the ground can be flooded or nearly so.

Common Red Spider (Tetranychus telarius.) Potatoes adjacent to weeds or to red clover sometimes are severely damaged by the red spider which migrates to them when other food becomes scarce. Affected plants are stunted, the foliage assumes a brownish cast, and the leaves become dry and brittle. Red spiders are tiny mites which feed mostly on the under surfaces of leaves, in time covering them with a dense web. Control is usually necessary only around the outer edges of potato fields and is obtained by dusting with finely powdered sulphur at the rate of 15 pounds per acre.

Grasshoppers. Grasshoppers frequently injure the outside rows of potatoes. They are readily and economically controlled by the use of poisoned bran mash as described in Idaho Extension Bulletin No. 80.

Plant Bug. Wilting tips of potato plants, which later turn brown and brittle, are produced by the feeding of plant bugs (so-called tarnished plant bugs). This insect is light green to brown in color, about one-fourth inch long, and may be recognized by the triangular mark on the back at the base of the wings. It often occurs in great numbers in potato fields. No direct method of control is known.

Seed Corn Maggot (Hylemyia cilicrura). Seed pieces frequently are attacked by small cream-colored maggots, larvae of a two-winged fly. Such attacks are believed to occur only after rot or decay of the seed piece has begun. Infestation is always most severe when prolonged cool, wet weather causes seed pieces to rot before they can sprout and grow. The flies deposit their eggs on the soil surface and the tiny maggots hatched are attracted to the decaying seed. When the stand is greatly reduced by failure of seed to sprout, the field may be replanted with assurance that the seed corn maggot will not attack the seed if weather conditions are favorable for normal sprouting.

Blister Beetles. Blister beetles are long, slender beetles which sometimes defoliate potato plants near the outside margins of the fields. The species in Idaho are gray, gray with black spots, shiny green, or shiny black in color. They are not often of sufficient importance to justify practice of control measures. When necessary, plants may be protected by spraying them heavily with lead arsenate at the rate of 4 pounds per 100 gallons of water or by dusting them heavily with calcium arsenate, barium fluosilicate or sodium fluosilicate.

VII. Growing Potatoes for Seed

THE importance of good seed potatoes can hardly be overestimated. A poor crop of potatoes seldom pays the cost of production. A big crop may give a net return of $200 or more per acre. The difference in yield is frequently a matter of good or bad seed potatoes.

The more unfavorable conditions of the unirrigated lands of Idaho tend by the struggle of the plant for existence to eliminate the weaklings, hence the average of the crop thus grown is improved in vitality.

In Idaho there is a great quantity of land in the north and in the foothills of the various mountain areas that is ideally adapted to growing seed potatoes. This land will not ordinarily grow a big yield because insufficient moisture usually limits the crop, but a crop of good seed potatoes from such lands will bring a greater return than most crops that can be grown on them.

For this purpose the deeper loam soils that are retentive of moisture should be selected. A northern or eastern exposure is preferable, as such lands are less affected by the hot south winds of midsummer. The chief essential for success in growing potatoes under these conditions is to keep the soil mellow and to retain the moisture. All items of culture must be planned and executed with these principles in mind.

Unless the soil is particularly light and mellow, the plowing should be deep (not less than 10 inches) and should be done in late fall. Leave the ground rough till spring so as to hold as much snow as possible. Harrowing should be done as early in the spring as the ground is fit to work to prevent the loss of the accumulated soil moisture.

Under certain conditions it is best to plow shallow in the fall, harrow consistently in the spring until June, then plow deeply and plant immediately.

Ten years' observation of seed potato growing in Idaho has shown that the best type tuber is produced when the planting is delayed until the latest possible date. This varies in the different altitudes from early June in the shortest season districts to early July in other places. When planting is delayed until these dates it is very essential that every condition be made favorable for a quick start and rapid growth of the plant. These factors are sufficient soil moisture and large seed pieces. Large seed is important for two reasons: the plant comes up more quickly than if small sets are used, and is larger and stronger. Large seed, however, needs a greater distance between plants in the row because the plants are larger, require more moisture, and also naturally produce a greater number of tubers than plants coming from small sets.

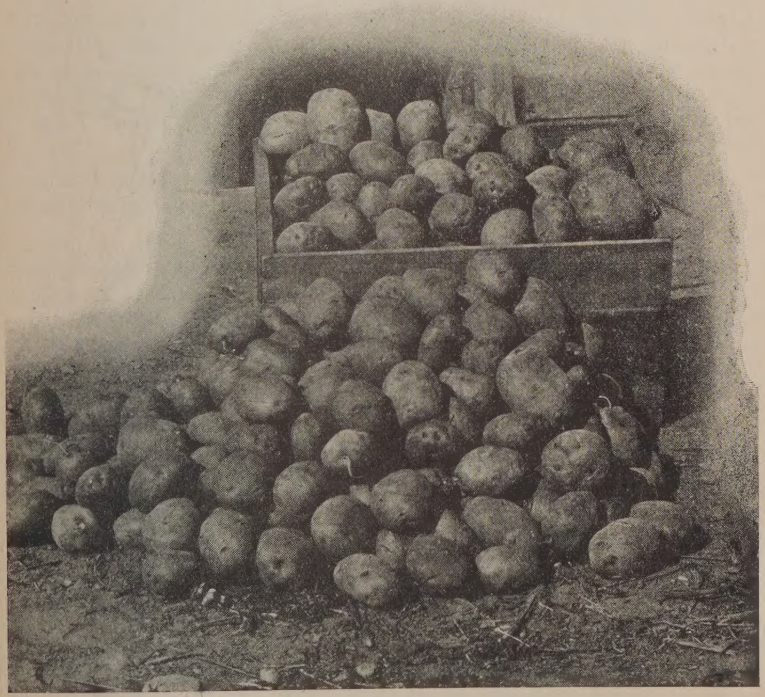
Greater distance in the row is a distinct advantage to the grower in roguing out weak and diseased plants as the individual plants can more readily be seen and the diseases identified.

It should be unnecessary to say that the value of any potato grown for seed depends entirely on what is planted. Culls, un-

desirable varieties, mixtures of varieties, diseased seed or undesirable types of good varieties planted and cared for in the best manner possible, necessarily produce potatoes that are valueless as seed stock. Hence the greatest of care must be exercised in getting a start in the work of growing seed potatoes.

Further than this, if a grower is to attain the greatest measure of success, he must improve and build up his strain of stock by selecting seed each year from the best plants in the field for planting his own seed plot.

All seed stock should be treated to clean it of scab, rhizoctonia, blackleg, and other disease germs that might be carried by the tubers, as described in Idaho Experiment Station Circular No. 58.



Good type Idaho Rural seed potatoes. Four to ten-ounce tubers

Probably the most vital point as to cultural methods in growing potatoes on unirrigated land is that of depth of planting. If they are planted shallow they are almost sure to suffer from lack of moisture at some time during the growing season and

a large per cent of the seed pieces are apt to dry out before the plants are started. Five inches under the level surface is none too deep for unirrigated plantings.

The same machines may be used for planting as for the market crop, but the machine planter is not so essential as when planting on irrigated land. A distance of 30x30 inches or even 3x3 feet may not be too great for planting. Because of this and because of the necessity for thorough, frequent, shallow cultivation, it is good practice to mark the land both ways and plant in the checks with a hand planter. Hand planters, costing a dollar or two, can be secured that will do good work and with which from one to two acres can be planted by one man in one day. Under this system but little, if any, extra investment for special tools is needed for the work.

Little need be said about cultivation. If the soil is loose, deep cultivation is unnecessary and in case of insufficient precipitation it may prove harmful. Weeds must, of course, be kept from growing. They not only rob the soil of plant food and moisture but they are also a menace in the carrying of potato diseases.

Harrowing with a spike tooth harrow until the plants are too large for harrowing, may give equally as good results and cost less than row cultivation.

Digging such seed stock may be done in any way that seems most feasible. For growers living at a considerable distance from shipping points, as many of them do, it is decidedly advantageous to get the crop to some shipping point for storage so that the potatoes may be delivered at any time they are wanted.

Do Potatoes Run Out?

A discussion of seed potato growing would be incomplete if nothing were said about the running out of potatoes.

We know that in certain districts a strain of potatoes changes its characteristic habit of growth and form of tuber and that the stock becomes generally attenuated when planted year after year in the same district. A large proportion of this so-called "running-out" is a simple case of disease contamination, although all the changes that take place in the characteristics of potato plants cannot be attributed to disease.

It is also known that this so-called "running-out" or degenerative change will take place in some districts in spite of any selection of the best plants or tubers that can be made. It is also true that these same strains of potatoes may be kept for a great number of years without deterioration when grown under some other climatic condition. In many cases, this environmental degeneration has never been satisfactorily explained.

The potato is native to the high altitudes of the mountains of South America. It is more at home and makes a more rapid normal growth in districts that approximate the conditions of its native habitat. This condition is secured with apparently equal success, either by the latitude of the northern states and Canada or by an altitude in states farther south which because of its height above sea level, provides the temperature that is desirable for the potato plant.

Another factor that must be considered is the change that has been made in the potato through domestication. The progenitor of our potato was a plant of similar habit of growth to the potato of today but the tubers were small and irregular in type and there were probably a greater number to the plant, considering its size and strength, than there are today. There has been a continuous selection, either consciously or subconsciously, to change this habit to produce a plant that yields larger tubers, even though fewer in number, and those with a greater percentage of food in their composition. In other words, nature produced tubers on the potato plant simply for the purpose of reproducing the plant and that as abundantly as possible. Man has, by selection, aimed to divert this tendenecy toward his needs, which require more edible tissue from each plant.

Under the most favorable conditions of climate and soil, nature tolerates this change, but where the environment is less congenial, there is an almost immediate attempt on the part of the plant to break up into forms, some of which may be adapted to the given conditions. Under such circumstances, the resulting forms could not be expected to be desirable from the standpoint of yield or quality of tuber.

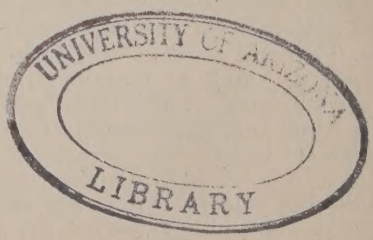
Much of the so-called "running-out" of potatoes is unquestionably due to bad selection. Sometimes the grower eats or markets the best of the crop, planting those that are too small to market. Some of the small potatoes are from high-yielding, healthy plants. Such seed will or should reproduce the characters of the parent plant. More of the undersized tubers are from weak, diseased, or degenerate plants; these will also reproduce their kind. Each year, the percentage of bad heredity is increased until the original type and capacity to produce profitable yields are lost. Then the stock is said to be "run-out." Planting culls is selection as surely as planting from the best plants. It produces results more quickly than good selection. It should be borne in mind that agricultural crops are made up of varieties and strains of plants that have been built up by more or less careful selection. A high standard can be maintained only by continuing the selection. It is but natural that the tendency in all plants should be to get back to the general average or even to

revert to the primitive standard, which may be far below that established by the work that has been done in developing the plant type.

Environmental influences will inevitably induce changes in the plant. These changes may be termed "running-out." Where the climate is favorable a less amount of variation and breaking up of the type may be secured and these changes may not be such as to be considered deterioration. Such changes, if more or less radical, are called "sports" or mutations. The Red Peachblow was derived from the White Peachblow in this way and the White Early Ohio is a color sport of the Red Early Ohio.

These changes in type or color of potatoes have given rise among many growers to the idea that potatoes mix or cross in the field. In other words, that if two varieties of different color or form are planted side by side some of the tubers or plants of the next generation will be affected so as to resemble both of the associated varieties. As previously stated the potato, as now known, is propagated asexually (by cuttings), hence, each year's crop is but a continuation of the preceding crop. This being true, it is botanically impossible for any crossing to take place except when potatoes are produced from true seeds. Even then it is doubtful if most potato seed obtainable is the result of the fertilization of the flowers of one variety by the pollen of the other variety.

The writer has had considerable experience in growing many distinct varieties, side by side, in experimental plots, and, although this work was carried on for a term of years, no evidence of any influence of one variety on another was ever detected. Conclusions then are, that while there need be no fear of potatoes mixing so as to change their character or type, there is a great probability of securing radical changes which may be either better or worse because of methods of selecting the seed stock with which to plant from year to year. It is also evident that under certain climatic conditions, while potatoes may be grown with profit, it is advisable to secure seed from other sources each year rather than to save it from the home-grown stock.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